CEO pay: power biased technological and institutional change [1]

by

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Abstract:
The microprocessor and related technologies have transformed corporate and industry structure; applied in a neo-liberal environment, the technologies have had profound effects on the relative power of different groups. Skott and Guy (2007) and Guy and Skott (2008) formalized one aspect of this process of *power-biased technical change*: firms' increased ability to monitor low-paid employees and the resulting changes in inequality and employment at the low end of the income distribution. This paper addresses power biases and income inequality at the high end. Increasing firm-level volatility and winner-take-all characteristics have intensified the agency problem and increased the power of corporate executives. These effects, which have been compounded by changes in ideology and pay norms, yielded an explosion in executive pay. We examine this hypothesis empirically using the firm-level volatility of operating income per employee and the industry-level standard deviation of operating income per employee as indicators of the severity of the agency problem. Observed patterns of CEO pay are consistent with the hypothesis.

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Key words: communications technology, power-biased technical change, inequality, executive pay, agency problem.

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1 Introduction

The importance of agency problems for the pay of top executives should not be controversial. There is a voluminous literature on the issue and compensation committees believe that the problems are critical. When the relationship between executive pay and technological change are discussed, however, agency problems tend to be ignored; implicitly the analysis excludes effects of technological change on the severity of the agency problems. This exclusion is unfounded.

New technologies have aggravated the agency problem for top executives by changing the structure of markets. They have done this in two ways. First, ICTs have, accentuated markets' winner-take-all (WTA) characteristics; second, both WTA markets, and a reduction in product life cycle time (von Braun 1990; Kurzweil 1992), contribute to an increase in firm-level volatility (Comin and Mulani 2006; Chun et al. 2008). WTA means that greater consequences ride on the choices made by top executives; firm-specific volatility exacerbates the information asymmetry between executives and shareholders. Thus, both WTA and volatility change the parameters of the agency problem. The result -- using standard agency arguments -- is a rise in executive pay.[4] We examine this hypothesis empirically using Compustat data. We find that indicators of volatility and WTA characteristics have strong statistical and substantive effects on CEO pay.

Agency problems – or contested exchange in the terminology introduced by Bowles and Gintis (1993) -- involve elements of power; the agent can influence outcomes that the principal care about, and by paying a wage premium the principal ensures agents who lose their job will suffer a loss. Technological change can affect the parameters of the agency problem; the change can be what we have called ‘power biased’. Skott and Guy (2007) and Guy and Skott (2008, 2008a) formalized one aspect of power-biased technologogical change: firms' increased ability to monitor low-paid employees and the resulting changes in inequality and employment at the low end of the income distribution; the installation of black boxes which allows owners to monitor truck drivers in real time represents a clear example. This paper addresses power biases and income inequality at the high end, with PBTC now applied to executives: new technologies and shorter product life cycles have led to a rise in executive power and pay. The argument stands in sharp contrast to theories of skill

[4] Our approach helps explain not only the rise in executive pay, but of any agent responsible for strategic decisions affecting corporate ownership or investment; critically, it applies to people involved in those choices from outside the corporation, such as investment bankers: both CEOs and investment bankers are decision makers with important private information in uncertain markets. Note also that we are explaining increases in *earnings* (salaries and business income); as Piketty and Saez (2003) show, the increased income share of the top 0.1% has, in the US, been primarily from those sources – in marked contrast to the top echelon's previous dependence on property income.

biased technological change (SBTC). Gabaix and Landier (2008), for example, attribute the explosion to the demand for scarce talent associated with a parallel rise in the market value of corporations; the high pay is seen as market-based and efficient.[5]

Our focus on technology and principal-agent problems should not be seen as a denial of the importance of the institutional framework. On the contrary, the effects of technology on market structure and executive pay are institutionally contingent.[6] The changes in market structure, first, affect the normative framework within which executives work. The volatility of firm level outcomes and the greater mobility of executives reduce attachment to employees; paying executives as if they were capitalists helps increase social separation between them and their subordinates, and increases identification (as well as incentive alignment) with their principals. On balance, these changes, we argue, accentuate the agency problem and contribute to the rise in executive pay. Second, and more important, ICTs create WTA markets because the state allows them to. Formal institutions create the framework within which, for instance, network products or intellectual property produce a WTA outcome. Competition policy, intellectual property law, labor market institutions, corporate governance institutions, and the tax system all affect both the distribution of gains within a given product market structure and the incentives to shape product markets in particular ways. Thus, rising executive pay -- and rising inequality, more generally -- should not be understood as one of technology rather than institutions. But the institutional problem needs to be understood as one of choosing how to regulate markets, given a particular technological endowment. The revolution in information and communication technologies has made new corporate structures and new market structures possible; post-1980 neo-liberal regimes represent a political choice to scrap mid-century regulation rather than adapting it to the new technologies.

This view of the linkages between technology and institutions stands in contrast to the SBTC literature which typically ignores any role of institutional change.[7] Our position is closer to the literature that attributes the rise in executive pay – and the rise in inequality generally - to

[5] One obvious problem with Gabier and Landier's analysis is that it ignores agency – a central question in the pay of CEOs since the work of Jensen and Meckling (1976), and Jensen and Murphy (1990). Another is that CEO pay has not always been so tied to market value. Before the explosion, pay at the top was a relatively steady function of pay on the bottom of the same companies (Simon 1957; Guy 2005); attributing the rise in pay to the rise in market valuation does not tell us why the two came to be tied together.

[6] Because of this contingency, 'power biased technological and institutional change' would be a more accurate terminology. The shorter PBTC, however, provides a nice counterpoint to SBTC.

[7] It is suggested – sometimes implicitly – that the simultaneous increase in both relative employment and relative pay of particular groups of workers can be explained only by SBTC. We reject this claim; PBTC can produce the observed pattern (Skott and Guy 2007) as can changes in the minimum wage in economies with 'overeducation' (Slonimczyk and Skott 2012).

institutional change; e.g. Atkinson (2000), DiNardo et al (1996), and Levy and Temin (2007). [8] It is somewhat unsatisfying, however, to treat a large *set* of institutional changes – what we can call neo-liberalism – as exogenous. We can, more reasonably although with necessary caveats, treat technological change as exogenous, and this literature typically ignores any possible interdependence between technological and institutional change.

Section 2 gives a brief overview of important changes in technology and their effects on market structure and the agency problem for CEOs (see Skott and Guy 2013 for a more extended discussion). Section 3 analyzes a benchmark model of CEO pay based on Shapiro and Stiglitz (1984). This analysis is followed by extensions that incorporate performance pay (Section 4) and social norms and ideology (Section 5). Observed patterns of CEO pay and their consistency with the agency argument are analyzed in Section 6. Section 7 concludes.

2 New technology, volatility and institutional contingencies

Prior to the financial crisis in 2007-2008, macroeconomists were fond of referring to the 'great moderation' to describe the fall in volatility of gdp and unemployment that had occurred from some time in the 1980s in many advanced economies. This reduction in the amplitude of fluctuations at the aggregate level did not, however, carry over to reduced volatility at the firm level. On the contrary, the firm level volatility of key variables, including operating income per employee, had been growing (Comin et al. 2009, Chun et al. 2011, Pastor and Veronesi 2009).

Both technological and institutional factors contributed to the growth in firm-level volatility. On the technological side, new information technologies involved increasing 'codification'. Tacit knowledge was turned into 'code'; that is, put in standard form that can be re-used and communicated. Obvious examples include computer software and genetically modified organisms.

Codification typically is a source of increasing returns to scale. The initial codification (writing the software program) can be extremely costly, but it reduces the marginal cost of production. [9] This implication is obvious in extreme cases like software, but similar trends apply more generally: the costs of designing products and processes have risen while the marginal costs of production have fallen for many goods and services. Importantly, however, product life cycles have become shorter and markets have become less stable (von Braun 1990, Kurzweil 1992). The result has been

[8] This literature is often coupled with critiques of the SBTC hypothesis (Card and DiNardo 2002; Howell 2002; Mishel et al. 2013).

[9] Network effects can amplify the winner-take-all tendency. Using the same software facilitates collaborative work; there is no point in being on a social networking site that others do not use; teenagers want to play computer games with their friends and their choice between Xbox and PlayStation depends on what their friends are using already.

a change from stable oligopoly markets to fluctuating winner-take-all markets. Examples abound. Nokia dominated the cell phone market just a few years ago (and Blackberry the market for smartphones); Apple meanwhile seemed a lost cause in the mid 1990s.[10]

New information technology (including transport technology) has also made it possible for outsourcing to explode. Here again codification plays a key role, enabling the necessary communication of technological and contractual information to allow arm's length coordination (Sturgeon 2002) . Production can be 'modularized', and firms can focus resources on their 'core competencies'. Outsourcing and modularity, in turn, are associated with the development of markets for 'corporate parts'. General Electric alone made more than 100 acquisitions over a five year period in the mid 1990s (Ashkenas et al. 1998). Mergers and acquisitions can be successful; GE is often seen as an example. But things can also go wrong; HP acquired the British company Autonomy paying more than $11 billion in 2011 but had to write down the value of the acquisition by 79 percent in 2012 (New York Times, 11/30/2012).

These developments have a technological side but there are crucial institutional contingencies. Microsoft's position, for instance, depends on intellectual property rights, including control of certain application program interfaces (APIs), such as document formats. If these interfaces were public property, software markets would have very low entry barriers, and could function largely as markets for customization and service (Stallman 1985; Raymond 1998). Intellectual property rights have been strengthened and extended to new categories over the last 30 years, including software (Freeman 1995, Sell and May 2001, Guy 2007, Boldrin and Levine 2008 ARE THESE THE RIGHT/BEST REFERENCES?). Industry regulation provides other examples. The UK forces cell phone providers to lease their networks to competitors; the US does not, and US cell phone users pay the price.[11] Google's internet position was strengthened by the Federal Trade Commission's decision that it would be allowed to present search results that highlight its own services.[12]

As a third set of examples, the effects of modularity also depend on institutional and regulatory factors. Most obviously, perhaps, trade policy and the deregulation of capital flows influence the outsourcing of production to China. Deregulation of labor markets and weak protections for

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[10] In 1995 the Economist (2/23/95) proclaimed, "Apple could hang on for years, gamely trying to slow the decline, but few expect it to make such a mistake. Instead it seems to have two options. The first is to break itself up, selling the hardware side. The second is to sell the company outright." According to BusinessWeek, "Apple went from hip to has-been in just 19 years" (2/5/96). The company's current success may under threat; it has been losing smartphone market share, and some observers are gloomy" (http://www.businessinsider.com/apple-is-being-greedy-2013-9)

[11] http://www.nytimes.com/2014/08/24/business/two-countries-two-vastly-different-phone-bills.html

[12] http://www.nytimes.com/2013/01/04/technology/google-agrees-to-changes-in-search-ending-us-antitrust-inquiry.html

employment and workers' rights also play a role by making it easier for executives to exploit modularity to cut costs.

For present purposes, the main point of this brief outline of technological and institutional changes concerns their impact on the agency problem for top managers: the changes have produced a rise in firm-specific volatility. This rise exacerbates the information asymmetry between executives and shareholders; owners will find it increasingly difficult to decide whether a bad performance by the firm was unavoidable, or the result of poor executive effort or judgment. The result is a rise in the power and pay of top executives.

3 A model of CEO pay

Some managerial activities target the efficient production of a chosen output; anything from organizing an efficient production line to payroll administration may fall into this operational category. But many of the activities of top management are what we may call portfolio activities: determining, for instance, what should be produced, where it should be produced, and how and where it should be sold. Collecting and analyzing information to decide pricing strategies, the direction of new R&D, the location of new factories, acquisitions or divestitures, outsourcing, or changes in financing -- none of this has anything to do with the technical transformation of inputs into output. Managerial time spent on decision making of this kind is neither a substitute for direct production inputs -- allocating more resources to making the right pricing decisions does not reduce the input requirements per output unit -- nor a complement to production in any technical sense; the efficient production of a given amount of widgets does not require that prices be set at the profit maximizing level. These portfolio activities have no place in a standard production function. They are needed because making the right ('profit maximizing') decisions is no trivial matter in an uncertain environment and because of the important consequences for the firm -- for better or worse -- of the choices that are being made.

As outlined in Section 2, new ICT in combination with regulatory and institutional changes have increased the range of portfolio options; the portfolio aspect of managerial activity has become increasingly dominant.[13] Skill based approaches to the explosion in executive pay highlight skill requirements, suggesting that new technology has raised the 'marginal product of the high-skill

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[13] This has been an ongoing process; Auerbach (1988) provides historical perspective on the changes in competition and managerial practice. The 'portfolio conception' of the firm has been emphasized by Crotty (2005, p. 88) who argues that there has been a shift

> "from an implicit acceptance of the Chandlerian view of the large NFC [non-financial corporation] … to a 'financial' conception in which the NFC is a 'portfolio' of liquid subunits that home-office management must continually restructure to maximize the stock price at every point in time."

managerial input'. But the fact that skill is involved does not prove that executives are uniquely skillful or even that it is the skill that is being rewarded; the responses of a long line of financial executives during the hearings of the Financial Crisis Inquiry Commission in 2010 did not suggest superhuman skill.[14]

The activities of top executives differ from the tasks of most production workers in another way. Strategic managerial decisions are indivisible and the effects of the decision are subject to great uncertainty. In hindsight, it may be obvious that HP should not have paid $11 billion to acquire Autonomy or that JP Morgan should have put in place mechanisms that could have prevented a $6 billion loss from the 'London Whale' trading. It may also seem obvious that Apple made the right decisions when they introduced the iPhone, but at the time it was not so obvious.[15] The indivisibility of the portfolio decisions, the high stakes, and the impossibility of monitoring the CEO and evaluating the decisions in advance aggravate the agency problems. As a result, high compensation may persist even if owners can choose from a pool of potential managers, all with exactly the same skills and known to have the same skills.

If the function of top managers is intrinsically -- and increasingly -- linked with uncertainty about the properties of the world in which the firms are operating, the derivation of an 'optimal, profit maximizing managerial pay' becomes questionable; a well-defined optimal pay only exists if most of what a CEO does would not be needed in the first place. Nevertheless, it may be possible to outline how changes in the firm's environment can influence pay in a stylized model with stochastic elements as a proxy for uncertainty.

For simplicity disregard operational inputs (assume that these are chosen efficiently or

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[14] Krugman (NYT 1/14/2010) commented that:

> "Well, if you were hoping for a Perry Mason moment --- a scene in which the witness blurts out: Yes! I admit it! I did it! And I'm glad! --- the hearing was disappointing. What you got, instead, was witnesses blurting out: Yes! I admit it! I'm clueless! [it was] startling to hear Mr. Dimon admit that his bank never even considered the possibility of a large decline in home prices, despite widespread warnings that we were in the midst of a monstrous housing bubble."

[15] Fred Vogelstein describes some of the issues in an article in the New York Times Magazine (http://www.nytimes.com/2013/10/06/magazine/and-then-steve-said-let-there-be-an-iphone.html?pagewanted=all):

> "It's hard to overstate the gamble Jobs took when he decided to unveil the iPhone back in January 2007. Not only was he introducing a new kind of phone — something Apple had never made before — he was doing so with a prototype that barely worked. Even though the iPhone wouldn't go on sale for another six months, he wanted the world to want one right then. In truth, the list of things that still needed to be done was enormous. …
>
> No one had ever put a multitouch screen in a mainstream consumer product before, either. Capacitive touch technology — a "touch" by either a finger or other conductive object completes a circuit — had been around since the 1960s. Capacitive *multitouch*, in which two or more fingers can be used and independently recognized, was vastly more complicated. … Even if multitouch iPhone screens had been easy to make, it wasn't at all clear to Apple's executive team that the features they enabled, like on-screen keyboards and "tap to zoom," were enhancements that consumers wanted."

alternatively, with a given level of competence) and focus on the portfolio activities -- pricing, investment, R&D, financing etc. -- that lie behind standard assumption of 'profit maximization'. The firm's profits before managerial pay depend on these decisions, and we write the profits as the sum of two terms,

$$\Pi = f(e;\mu,A) + \lambda\varepsilon \tag{1}$$

We focus on CEO pay and assume a single manager. The first term in f relates profits to the CEO's 'effort' (e). As in efficiency wage models generally, effort should be seen as a shorthand for acting diligently and in the best interest of the principal. Thus, effort includes not just putting in the effort that allows sensible decisions to be made but also the making of the 'right' decisions, given the evidence, as opposed to skewing decisions in ways that favor managers at the expense of owners; wasteful expenditures on corporate jets or the manipulation of indicators that determine managerial remuneration are obvious examples of the latter decisions. The parameters μ and A determine the shape and position of the f -function: an increase in μ raises the sensitivity of profits to managerial effort; an increase in A produces an upward shift in the profit function, raising profits uniformly for any level of effort. The second term is a random shock; ε is a stochastic variable with mean zero and variance σ^2; an increase in the parameter λ corresponds to a more risky environment.

New ICT and associated regulatory and institutional changes have affected the parameters A,μ,λ . Options to outsource, for instance, and the effects of this option on domestic wages have provided new sources of cheap labor and raised profits for any given managerial effort; the emergence of a range of new options have increased the sensitivity of the outcome to effort; a less stable and more uncertain business environment have increased both the sensitivity of profits to effort and the variance of the firm-specific random component.

These changes and their effects can be formalized using a modified Shapiro-Stiglitz (1984) model. CEOs are hired from a pool of identical candidates; both the number of CEO positions and the size of the pool of potential CEO candidates are taken as constant. A CEO either provides low effort (shirks) or high effort. Assuming a simple linear version of (1), the corresponding profits in period t are

$$\Pi_t = \begin{cases} A + \mu + \lambda\varepsilon_t & \text{with high effort} \\ A - \mu + \lambda\varepsilon_t & \text{with low effort} \end{cases} \tag{2}$$

The CEO's performance is evaluated at the end of each period. Effort cannot be monitored directly; the evaluation is based entirely on the observable variable, Π_t. The CEO is fired if Π_t falls below a threshold M. The value of M determines the firing rates for both non-shirking and shirking CEOs.

A CEO maximizes

$$E\{\sum_0^\infty (1-\rho)^t u_t\} \tag{3}$$

where

$$u_t = \begin{cases} w - v & \text{if holding a CEO position and providing high effort} \\ w & \text{if holding a CEO position and providing low effort} \\ b & \text{if "unemployed"} \end{cases} \tag{4}$$

The utility b from being unemployed (having a non-CEO position) and the disutility v of supplying high effort are exogenously given in this version of the model; ρ is the discount rate. CEO pay (*w*) is treated initially as a simple wage; the modifications associated with performance pay are considered in Section 4.

Standard derivations (see Appendix A) give the following no-shirking condition:

$$w^{no-shirk} = b + [1 + \frac{\rho + (1-\rho)(\delta + q)}{(1-\rho)p}]v \tag{5}$$

where δ is the separation rate for non-shirkers, p the firing rate associated with shirking, and q the hiring rate for currently unemployed managers. The hiring rate q is exogenous to a single firm. The values of δ and p, by contrast, are determined by the firm's firing threshold, M. The separation rate for non-shirkers has an autonomous rate δ_0 and a performance related component; depending on the threshold *M*, unlucky, non-shirking CEOs may be fired.

The values of M and w are set to maximize profits net of CEO compensation:

$$\max E\Pi - w$$

$$s.t.$$

$$E\Pi = \begin{cases} A+\mu & \text{if } w \geq b + [1 + \frac{\rho+(1-\rho)(\delta+q)}{(1-\rho)p}]v \\ A-\mu & \text{otherwise} \end{cases} \tag{6}$$

We assume that ε follows a uniform distribution on the interval [-1,1],

$$\varepsilon \sim R(-1,1) \tag{7}$$

Given this assumption and the firing condition, we have

$$\delta = \begin{cases} 1 & \text{if } \frac{M-A-\mu}{\lambda} \geq 1 \\ \delta_0 + (1-\delta_0)(\frac{1}{2} + \frac{1}{2}\frac{M-A-\mu}{\lambda}) & \text{if } 1 > \frac{M-A-\mu}{\lambda} > -1 \\ \delta_0 & \text{if } -1 \geq \frac{M-A-\mu}{\lambda} \end{cases} \tag{8}$$

$$p+\delta = \begin{cases} 1 & \text{if } \frac{M-A+\mu}{\lambda} > 1 \\ \delta_0 + (1-\delta_0)(\frac{1}{2} + \frac{1}{2}\frac{M-A+\mu}{\lambda}) & \text{if } 1 > \frac{M-A+\mu}{\lambda} > -1 \\ \delta_0 & \text{if } -1 > \frac{M-A+\mu}{\lambda} \end{cases} \tag{9}$$

[Figure 1 about here]

A profit maximizing firm will pay either the no-shirking wage given by (5) or the reservation wage *b*. Consider first the determination of *M* in the no-shirking case. The wage is a function of p and δ, and the values of p and δ are fully determined by *M* (cf. equations (8)-(9)). Tedious calculations show that in this no-shirking case the optimal value of *M* is given by (see appendix B and Figure 1)

$$M^* = A + \mu - \lambda \tag{10}$$

The intuition behind equation (10) is straightforward. An increase in the firing rate for CEOs that do not shirk raises the effective discount rate and dilutes the incentive to provide effort. Thus, the increase could only be justified if it hurt shirkers more than non-shirkers; with a uniform distribution of the shock, however, non-shirkers will be hurt at least as much as shirkers by an increase in *M* above the expression for *M** in (10)). It follows that *M** cannot be greater than the expression in equation (10). On the other hand, shirkers should be punished if it can be done without hurting the non-shirkers; *M** therefore cannot be less than the expression in (10)).

Combining equations (8)-(10), we get solutions for δ, p and q :

$$\delta = \delta_0 \tag{11}$$

$$p = (1-\delta_0)\min\{1, \frac{\mu}{\lambda}\} \tag{12}$$

In a steady state the flows into and out of employment are equal,

$$q = \delta_0 \frac{n}{1-n} = \theta\delta_0 \tag{13}$$

where n is the employment rate for CEOs. By assumption the number of CEOs and the pool of potential candidates are constant; thus, the employment rate n and $\theta = n/(1-n)$ are constant too.

Plugging the solutions for p, δ and q into the expressions for w and $E\Pi - w$, we get

$$w^{no-shirk} = b + [1 + \frac{\rho + (1-\rho)\delta_0(1+\theta)}{(1-\rho)(1-\delta_0)\min\{1, \frac{\mu}{\lambda}\}}]v \tag{14}$$

$$\begin{aligned} &E\Pi^{no-shirk} - w^{no-shirk} \\ &= A + \mu - b - [1 + \tfrac{\rho + (1-\rho)\delta_0(1+\theta)}{(1-\rho)(1-\delta_0)\min\{1, \frac{\mu}{\lambda}\}}]v \end{aligned} \tag{15}$$

The expression in (15) has to be compared with the profits that are obtained when the no-shirking condition does not hold and the CEO is paid the reservation wage, b :

$$E\Pi^{shirk} - b = A - \mu - b \tag{16}$$

The firm will want to pay the high, no-shirking wage if

$$\begin{aligned} &E\Pi^{no-shirk} - w^{no-shirk} - (E\Pi^{shirk} - b) \\ &= 2\mu - [1 + \frac{\rho + (1-\rho)\delta_0(1+\theta)}{(1-\rho)(1-\delta_0)\min\{1, \frac{\mu}{\lambda}\}}]v \quad > 0 \end{aligned} \tag{17}$$

This condition is satisfied if μ is sufficiently large, that is, if profits before CEO pay are sufficiently sensitive to CEO effort. We assume that the condition is met; without the condition, the agency problem becomes uninteresting.

[Figure 2 about here]

We are left with two cases (see Figure 2). If $\lambda < \mu,$ the range of possible profits under a shirking manager does not overlap with the range of profits under a non-shirking manager. Loosely speaking, the degree of uncertainty is small relative to the sensitivity of profits to managerial effort. As a result, realized profits fully reveal whether the manager has been shirking and marginal variations in A, μ and λ have no effect on managerial pay.

The more interesting case arises when uncertainty is high and $\lambda > \mu$ (Figure 2b). In this case, it follows from equation (14) that:

- an increase in A has no effect on CEO pay
- an increase in μ *reduces* CEO compensation and raises profits. The reason is simple. A higher sensitivity makes it easier to determine whether the CEO is shirking; the agency problem is alleviated.
- an increase in λ raises CEO compensation and reduces profits.
- a proportional increase in μ and λ leaves CEO compensation unchanged and enhances profits net of CEO compensation.

4 An extension: performance pay

The absence of performance related pay in the model may seem a serious weakness. Stock options and other performance related remuneration packages clearly play a large role in executive pay, and these elements of executive pay are often touted as a way to solve or at least alleviate the agency problem. This claim is questionable. There is substantial evidence that CEO pay responds as much to performance shocks that are clearly beyond the control of the CEO as it does to a shocks for which a CEO may possibly claim credit (Bertrand and Mullainathan 2001). Performance pay can also be undermined by other practices; the incentive effects of stock options, for instance, can be reduced or eliminated if CEOs sell off shares they own already or hedge their exposure to the firm. Thus, the true incentive element in what passes for performance pay is much smaller than it appears. Indeed, managers have an incentive to obscure and legitimize---or, more generally, to camouflage---their extraction of rents (Bebchuk et al. 2002, p. 756), and this may help explain the structure of managerial pay. The pay structures may in fact bring its own distortions as managers strive to augment the particular performance indicators that determine their pay; the distortions may include a focus on short-term profits (or immediate stock market gains) at the expense of long-term investment.

Disregarding these broader questions concerning the actual pay structures and their incentive effects, deviations from a simple fixed wage can be introduced without affecting the qualitative outcome. Assume that a firm's profits are affected by two distinct shocks, a general shock to the industry or the economy as a whole (ε_{At}) and a firm specific shock (ε_{ft}),

$$\Pi_t = \begin{cases} A+\varepsilon_{At}+\mu+\lambda\varepsilon_{ft} \\ A+\varepsilon_{At}-\mu+\lambda\varepsilon_{ft} \end{cases} \tag{18}$$

The shocks e_{At} and ε_{ft} are still taken to independent and uniformly distributed on the interval from -1 to 1 .

Total CEO pay to a non-shirker -- including a fixed component w_0 and performance pay -- can now be represented by the expression

$$w_t = w_0 + \gamma_1(A+\varepsilon_{At}) + \gamma_2(\mu+\lambda\varepsilon_{ft}) \tag{19}$$

The coefficient γ_1 captures the influence of general shocks on pay, γ_2 the influence of CEO effort and firm specific shocks.[16] By assumption CEOs are risk neutral in a Shapiro-Stiglitz setting, and the expected utility in period t can be written

$$Eu_t = \begin{cases} w_0 + \gamma_1 A + \gamma_2\mu - v = w - \tilde{v} & \text{if holding a CEO position and providing high effort} \\ w_0 + \gamma_1 A - \gamma_2\mu = w & \text{if holding a CEO position and providing low effort} \\ b & \text{if "unemployed"} \end{cases} \tag{20}$$

where $w = w_0 + \gamma_1 A - \gamma_2\mu$ and $\tilde{v} = v - 2\gamma_2\mu.$ For a given value of the performance coefficient γ_2, the structure of the decision problem is unchanged compared to section 3 as long

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[16] Bertrand and Mullainathan 2001 refer to the effect of γ_1 'luck'. It should be noted, however, that the effect of γ_2 also includes luck (as well as CEO effort). The difference in the luck component is that in one case the luck derives from a general shock that affects many firms, in the other it derives from a firm specific shock. Bertrand and Mullainathan find that no statistically significant difference between γ_1 and γ_2 in their full sample of companies.

as $\tilde{v} > 0$. Or putting it differently, unless the pay package succeeds in eliminating the agency problem, the principal will want to offer an (expected) wage premium to induce high effort.

5 An extension: fairness and changes in reference groups

There is abundant evidence that pay packages fail to eliminate the agency problem, but some of the reasons for this failure may also undermine standard efficiency wage models, including the Shapiro-Stiglitz version. These models assume that the principal understands the determination of effort and that the wage is set optimally. Given this understanding, however, why would the principal accept a pay structure that does not fully address the agency problem? In the simple model, why not raise γ_2 to ensure that $\tilde{v}$ becomes negative?

Bertrand and Mullainathan (2000), for instance, emphasize 'skimming': CEOs according to this view have great control over the pay-setting process but their greed is constrained by an 'unwillingness to draw shareholders' attention" (Bertrand and Mullainathan (2001, p 902). It would seem to strain credulity, however, to suggest that shareholders in oil companies fail to notice movements in oil prices or to recognize the implications for profits. It is also implausible that they should credit their CEO with having produced a rise in oil prices. But why then award a pay increase to the CEO? Shareholder inattention seems an inadequate explanation.

The skimming argument is similar to the ‘managerial power approach' (Bebchuk et al 2002). Benchuk et al. suggest that "whether a compensation arrangement that is favorable to executives but suboptimal for shareholders is adopted will depend on how the arrangement is perceived by outsiders and, in particular, on how much outrage (if any) it is expected to produce." To avoid outrage CEOs may try to camouflage high pay by making look as pay for performance. [17] But an important determinant of "outrage" comes from social norms. To create outrage, the pay must violate commonly accepted standards; "for outrage to impose significant costs it must be sufficiently widespread among the relevant groups of people" (p. 787).

Efficiency-wage arguments can be cast in different ways. In sections 3-4 we deliberately chose a version that is standard in the literature and that also seems to fit traditional Marxian notions of

[17] Outside compensation consultants and the construction of 'peer groups' to get a benchmark for compensation can be used deliberately to justify pay and avoid outrage (Wade et al 1997).

labor discipline.[18] Social norms can be introduced into a Shapiro-Stiglitz framework by letting the disutility v reflect the prevailing norms of fairness. The interpretation is straightforward. The disutility of providing effort that benefits someone else depends on one's feelings towards that someone; if the owners have been treating the CEO well, the disutility will be low.

Formally, let

$$v = \phi(\frac{w}{w_a}, \gamma); \quad \phi_w < 0, \phi_\gamma > 0 \tag{21}$$

where w_a is a reference wage and γ represents a shift variable. There is widespread evidence that 'fair wages' are determined in relation to a reference wage. Thus, the first argument in (21) is the relative pay w/w_a, rather than the absolute wage w. Reciprocating an increase in the relative wage, the CEO is motivated to raise effort; that is, the disutility of effort is decreasing in the relative wage. The shift variable γ in equation (21) is a catch-all for other factors that influence pay norms, including the general ideological climate; the Reagan-Thatcher years, for instance, heralded a shift in attitudes on issues ranging from inequality to the limits on socially acceptable greed and self-promotion.

It seems reasonable to suppose that the reference wage w_a contains (at least) two elements: the average wage paid to other CEOs ($\bar{w}$) and the average wage paid to the firm's production workers (z). As a simple formalization, the reference wage can be written as a weighted average,

$$w_a = \alpha\overline{w} + (1-\alpha)z \tag{22}$$

The composition of the reference group may change, however; specifically, the value of α may have increased over the last 30 years. Evidence of this shift can be found in the increasing-- and increasingly formalized -- weight of CEOs of comparable companies in compensation committees' decisions (Elson and Ferrere (2012)).[19]

The implications of an increase in α follow directly from equations (14), (21)-(22). Substituting (21)-(22) into (14), using the equilibrium condition $w = \bar{w}$, and taking total derivatives, we get

[18] Formulations that emphasize fairness and reciprocity may have more empirical support than the Shapiro-Stiglitz version; Akerlof and Yellen (1990) introduced fairness norms as a basis for efficiency wage models, and the survey evidence reported by Bewley (1999) strongly supports this approach.

[19] The shifting weights are not surprising. The volatility of firm level outcomes raises the cost of attachment to employees; paying CEOs as if they were capitalists helps increase social separation between them and their subordinates, and increases identification (as well as incentive alignment) with their principals.

$$\frac{dw}{d\alpha} = \frac{-B\phi_w \frac{w(w-z)}{[\alpha w+(1-\alpha)z]^2}}{1-B\phi_w \frac{(1-\alpha)z}{[\alpha w+(1-\alpha)z]^2}} > 0 \qquad (20)$$

where $B = 1 + \frac{\rho+(1-\rho)\delta_0(1+\theta)}{(1-\rho)(1-\delta_0)\min\{1,\frac{\mu}{\lambda}\}}$.[20] The net effect of the shift in the composition of the reference group is a rise in executive pay. This result is quite intuitive. The numerator in (23) is positive because the reference wage is increasing in α (equation 22), an increase in the reference wage raises the disutility of effort, for given w (equation 21), and an increase in the disutilty v raises the wage *w*; the denominator is greater than one, reflecting the dampening effects of a rise in *w* on the disutilty of effort. An analogous result can be derived for changes in the autonomous component *γ*; we have *dw/dγ>0.*[21]

This extended Shapiro-Stiglitz model shows how shifts in pay norms – whatever the sources of the shift – can be a direct, non-market influence on the evolution of CEO pay. An increase in pay to the CEO is matched by a decline in net profits to owners without any necessary, derived effects on relative factor inputs. Thus, our analysis supports the emphasis on institutional and ideological factors (e.g. Atkinson 1998, Levy and Temin 2007, Piketty and Saez (2003) , Mishel et al. 2012, Elson and Ferrere 2012). Non-market forces are brought in to determine distribution.

A similar indeterminacy in the division of gross profits arises in matching models with match-specific rents. The indeterminacy in this alternative setting can be resolved by using a Nash bargaining model and assigning 'bargaining power' to the two parties. As in the efficiency wage setting, the outcome depends on power, and in many respects the conclusions from the two models

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[20] Arguably, neither the steady-state assumption nor the full intertemporal optimization underlying the derivation of equation (14) in section 3 fit well with a norm-based approach. But fairness norms and reciprocity may produce a reduced-form equation of the same form as (14); that is,

$$w = b + Bv$$

with $B = B(\frac{\lambda}{\mu})$, $B' > 0$.

[21] For simplicity we have left out endogenous elements in the formation of norms: fairness norms adjust over time in response to actual achievements. According to Kahneman et al. (1986, p. 730-1)

> "any stable state of affairs tends to become accepted eventually, at least in the sense that alternatives to it no longer readily come to mind. Terms of exchange that are initially seen as unfair may in time acquire the status of reference transaction. Thus, the gap between the behaviour that people consider fair and the behavior that they expect in the market-place tends to be rather small."

Skott (2005) includes endogenously changing pay norms in a model with two types of workers. Atkinson (1998, p. 19) also notes the endogeneity, arguing that

> "As more people are remunerated outside the conventional norms, so adherence to these norms becomes weaker, and the socially acceptable range of remuneration becomes wider."

may be similar. The advantage of the efficiency wage version, in our view, is that it highlights the agency problem and directs attention to factors that determine relative power; increasing uncertainty (volatility), for instance. Even when it comes to norm-based effects, the agency setting provides a clearer and in our view more convincing story: CEOs gain power from their ability and willingness to hurt the interests of the owners. Thus, a change in pay norms has a direct effect on pay because it influences the willingness of the CEOs to hurt owners by providing less effort.[22] If CEOs feel badly treated at pay rates below $10 million, firms may have to pay $10 million to avoid shirking.[23] This fairness perspective is implicit in Elson and Ferrere's (2012) account of boards and compensation committees' choice of median (or above median) pay as the target:

> "If a board were to award lower than expected pay by compensating below median (market), it is understandable that there may be psychological consequences as a result of perceived inequitable treatment … Theories of pay equity suggest that when paid less than one's peers, a person may seek redress through the withdrawal of effort." (pp. 38-39)

It should be noted, finally, that social norms can magnify the effects of market induced changes in agency pay. If an increase in the severity of the agency problem raises the pay for managers in particular sectors, social norms and comparisons can produce ratchet effects across other sectors. In fact without these broader social effects, it increase in volatility would seem insufficient to explain the explosion in top managerial pay. Putting it differently, the effects of technological and institutional changes on the agency problem have been amplified by changes in social norms of fairness; levels of pay that would have seemed obscene not so long ago have become socially acceptable, and attempts to pay below the new norm may provoke a reduction in 'effort'.

6 Data and Preliminary Statistical Results

Our data source is Compustat, which provides financial data for publically listed US firms since the 1960s, and data on CEO pay from 1992 onwards.

[22] In economics, the strategic role of emotions has been stressed by Frank (1988).

[23] The correlation between firm size and CEO pay, according to this perspective, may owe as much to the widespread view that pay ought to be related to size and CEO responsibility as it does to more objective differences in the severity of the agency problem.

Our estimate of firm-specific volatility, following Chun et al. (2011) is based on real operating income per employee.[24] Let

$$GOPER_{i,t} = OPER_{i,t} - OPER_{i,t-1} \tag{21}$$

where OPER denotes (real operating income before depreciation) / (number of employees) and where nominal operating income is adjusted using the BEA value-added deflator for the relevant industry. Now consider the regression

$$GOPER_{i,t} = a + b1*GOPER_{INDUSTRY,t} + b2*GOPER_{ALL,t} + u_{i,t} \tag{22}$$

$GOPER_{INDUSTRY,t}$ accounts for the industry-wide rate of growth, while $GOPER_{ALL,t}$ accounts for macroeconomic changes. For each observation (i,t) this regression is calculated for a window of up to [t-9, t] (some windows are smaller due to data limitations. Our measure of firm-level volatility is then:

$$lnVOL\_FS_{i,t} = \ln(\text{residual sum of squares} / n) \tag{23}$$

where n is the number of observations actually used to estimate the particular regression (10 in most cases). We estimate lnVOL_FS for the period 1992-2012. Figure 3 shows the change in the mean value of lnVOL_FS over time. The rise is fairly steady from 1992 until 2009.[25]

[Figure 3 about here]

While the trend in mean volatility is strong, cross-sectional dispersion is considerable. Box plots of the distribution of lnVOL_FS, by year, are shown in Figure 2. These plots, following Tukey (1977), can be read as follows: the central line in each box shows the median for the year, the limits of the box show the inter-quartile range (25%-75%); the whiskers above and below the boxes extend 1.5 times the range of the quartile from which they extend; points beyond the whiskers are plotted individually, and can be regarded as outliers. The large number of outliers on these plots indicates large, fat tails to the distribution, especially at the upper end. The effects on our estimates of both the skew and the fat tails is something we need to investigate.

[Figure 4 about here]

Our measure of an industry's winner-take-all characteristics is

$$WTA_{INDUSTRY,\,t} = SD(OPER_{INDUSTRY,\,t}) \tag{24}$$

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[24] Value added per employee would be an alternative measure. Compustat's coverage of payroll costs is very patchy, however, and this measure would require the use of industry average wages in place of actual values for firms.

[25] The dip in 2002-3 is consistent with the levelling off found by Chun et al. However, Chun et al found the dip continuing to the end of their series (2006); for them this was evidence that the rise in firm-specific volatility had been associated with the adoption of a new general purpose technology (computers), and that this had now passed. Chun et al used the same dataset but different measures of volatility - growth of TFP and of factor inputs. This discrepancy in estimates requires further investigation.

Figure 5 shows the annual means, weighted by observations in the industry, of WTA.

[Figure 5 about here]

In the theoretical discussion above, we argued that firm-specific volatility aggravates the problem of asymmetric information between shareholder and CEO, because its firm-specific nature reduces the value of external benchmarks for performance. On the other hand, we associate high cross-sectional variance at the industry-level with a winner-take-all situation. In agency terms, higher cross sectional variance makes outcomes for the shareholders more sensitive to choices by the CEO: rather than the stable oligopolies of the mid-twentieth century, we see turbulent monopolies. The distinction between volatility and WTA may be cleaner in theory than it is empirically (at least using our current empirical indicators): high firm-specific volatility may be reflected in high cross-sectional variance, and high cross sectional variance may come close to measuring *expected* firm-specific volatility. It may be that the hypothesized relationships would be better captured by variables something like (i) fitted – that is, expected – volatility for the firm, and (ii) the cross sectional variance of actual volatility in the industry.

The trend in CEO pay in our sample is shown in Figure 6. While the real increase in the period 1992-2012 was substantial, the rise is not as steady as that of our volatility and WTA measures. Observations for CEO pay are quite sparse in the early years of the sample. It is likely that the sample properties change, so the time trend needs to be treated with caution; this is less of a problem for our empirical estimates, below, since the estimator is dealing primarily with within-firm variation.

[Figure 6 about here]

For 12,124 firm-years between 1993 and 2012, we have the relevant financial data, volatility estimates, and CEO pay data. Summary statistics are given in Table 1 – the units are logarithms of real thousands (CEO) or millions (sales), so the numbers are useful only in comparing years and interpreting regression coefficients.

[Table 1 about here]

The earnings equation for the CEO is:

$$\text{logCEO pay}_{i,t} = a_{i,t} + b1 * \text{logVOL\_FS}_{i,t} + b2 * \text{WTA}_{IND,t} + b3 * \text{logSales}_{i,t} + b4 * \text{Profit Rate}_{i,t} + u_{i,t} \qquad (25)$$

The first two regressors are described above. Sales (log of real sales) is a measure of firm size, as standard in CEO pay models. The Profit Rate is return on capital employed (ROCE):

$$\text{ROCE} = (\text{Earnings before interest and taxes})/(\text{Total assets} - \text{current liabilities}) \qquad (26)$$

CEO pay is Compustat's measure of total CEO pay, deflated using the CPI and expressed in logarithms.

Our preferred estimator for (25) is a random coefficients, or mean group, estimator of the Swamy/Hildreth-Houck type, which computes a separate dynamic estimate for each firm and then a weighted average of the coefficients. We can't do that this week because we need a more powerful version of Stata. However, as Pesaran and Smith (1995) show, the between estimator – a simple panel estimator that consists of a cross sectional regression on the means for each group (i.e., each firm) - gives a good approximation of random coefficients / mean groups results (for a previous application of the two, see Guy (2000). In Table 2, we report between estimates of equation 25.

Model 1 includes neither the volatility measure nor the WTA measure, and is reported for reference. The firm size (lnSales) elasticity and profit rate coefficients are within the range commonly found in the literature. Model 2 includes the Volatility variable, Model 3 includes WTA, and Model 4 includes both. In light of our concerns that these may be different ways of measuring the same thing, it is notable that neither effect changes substantially when both variables are in the model.

Referring to the descriptive statistics, the coefficients from Model 4 imply that a one SD increase in WTA produces a 0.05SD increase in equilibrium CEO pay, while a one SD increase in lnVOL_FS produces a 0.11SD increase in CEO pay.

These results must be seen as exploratory: both the variables and the regression specification need further work. What they suggest, thus far, is a relationship between CEO pay and both firm-specific volatility and winner-take-all markets which is statistically significant, and small but not trivial.

7 Conclusions

The ratio of CEO pay to average pay in Fortune 500 companies has gone from xxx in 1970 to xxx in 2013. In itself, this explosion in CEO pay calls for explanation. But executives, managers, supervisors and financial professionals account for about 60 percent of the top 0.1% income earners (Bakija et al. 2012); understanding CEO pay therefore is also important for an understanding of general trends in inequality at the upper end of the distribution.

Many factors undoubtedly have played a part, including skill (e.g. Murphy and Zábojník 2004; Garicano and Rossi-Hansberg 2006; Gabaix and Landier 2008). From a skill perspective, pay has increased because profits have become increasingly sensitive to variations in the quality of the managerial input. In the context of corporate governance, however, it would seem critical to consider agency issues. New technologies and institutions -- and the consequent changes in market structure -- affect the severity of the agency problem and thereby the power of CEOs.

Our model focuses on the agency issues – by assumption, skill differences among CEOs are absent in the model. But in other ways the benchmark model in section 3 is quite conventional and 'economistic': the CEOs have standard, exogenously given utility functions; it is assumed that firms have full knowledge of the various parameters underlying the choice of effort; uncertainty is replaced with a simple stochastic element. One difference compared to most of the agency literature on CEO pay is that we did not look for optimal contracts. Empirically there is a lot of evidence that contracts are far from optimal, and the benchmark model in Section 3 can be extended to include elements of performance pay without changing the qualitative conclusions (Section 4). Thus, the suboptimality of the structure of the compensation package does not represent an critical weakness of the model. The rationality assumptions behind the determination of the no-shirking level of pay seem more questionable. Our second extension (Section 5) relaxed these elements and introduced social norms. These broader sociological forces do not negate all elements of rationality; thus, outcomes in the extended model are influenced by social norms as well as by the technological and institutional determinants of the severity of the agency problem.

It could be interesting to relax some of the simplifying assumptions and extend the model further. But the simplifications do not, we believe, distort the basic argument: increasing uncertainty and changing social norms have exacerbated the agency problem and contributed strongly to the explosion in executive pay.

Our econometric results are consistent with the agency argument; the indicators of volatility and WTA characteristics are highly significant, both statistically and substantively. The regressions, however, should be seen as preliminary. We still have not found a good way to include broader changes in norms and ideology, our indicators of volatility and WTA characteristics have weaknesses, and the results may be consistent with other interpretations.[26]

[26] It is possible, for instance, that high-volatility firms operating in a challenging environment offer high pay in order to attract the most skilled CEOs.

Appendix A: Derivation of the no-shirking wage and expected profits

The CEO maximizes

$$E\{\sum_0^\infty (1-\rho)^t u_t\}$$

where (A1)

$$u_t = \begin{cases} w - v & \text{if holding a CEO position and providing high effort} \\ w & \text{if holding a CEO position and providing low effort} \\ b & \text{if "unemployed"} \end{cases}$$

The utility b from being unemployed (having a non-CEO position) and the disutility v of supplying high effort are exogenously given; ρ is the discount rate.

The value functions for employed CEOs satisfy

$$\begin{aligned} V_E &= w - v + (1-\rho)[(1-\delta)V_E + \delta U] \\ V_S &= w + (1-\rho)[(1-\delta)V_S + \delta U] \end{aligned} \qquad \text{(A2)}$$

where V_E and V_S are the value functions for managers with high and low effort, and U the value function for an unemployed manager. The no-shirking condition requires that $V_E = V_S = V$, and U is given by

$$U = b + (1-\rho)[qV - (1-q)U] \qquad \text{(A3)}$$

Using (A2)-(A3) we get

$$\rho V = w - v + (1-\rho)\delta[U - V] \qquad \text{(A4)}$$

$$\rho V = w + (1-\rho)(\delta + p)[U - V] \qquad \text{(A5)}$$

$$\rho U = b + (1-\rho)q[V - U] \qquad \text{(A6)}$$

Subtracting (A5) from (A4),

$$V - U = \frac{v}{(1-\rho)p} \qquad \text{(A7)}$$

and, using (A4) and (A6),

$$\rho(V - U) = w - v - b - (1-\rho)(\delta + q)[V - U] \qquad \text{(A8)}$$

Hence,

$$w = v + b + \frac{\rho + (1-\rho)(\delta + q)}{(1-\rho)p} v = b + [1 + \frac{\rho + (1-\rho)(\delta + q)}{(1-\rho)p}]v \tag{A9}$$

The flows into and out of employment are equal in a steady state. Wages are set to satisfy the no-shirking condition, the outflow is given by δ, and it follows that

$$q(1-n) = \delta n \tag{A10}$$

where *n* is the employment rate. By assumption both the number of CEOs and the size of the pool of potential managers are constant; n therefore is also constant. Letting

$$\theta = \frac{n}{1-n} \tag{A11}$$

the wage equation can be written

$$w = b + [1 + \frac{\rho + (1-\rho)\delta(1+\theta)}{(1-\rho)p}]v \tag{A12}$$

Appendix B: Choice of firing threshold

From (A12) it follows that M should be chosen to minimize the ratio

$$\frac{\rho + (1-\rho)q + (1-\rho)\delta}{(1-\rho)p} \tag{B1}$$

The values of ρ and q are exogenous to the firm; the separation rates δ and ($\delta + p)$ for high and low effort managers are determined by $M.$ Using (8)-(9) -- see also figure 1 -- we get

$$\frac{\partial(\delta + p)}{\partial M} = \frac{\partial \delta}{\partial M} > 0, \frac{\partial p}{\partial M} = 0 \text{ if } A - \mu + \lambda > M > A + \mu - \lambda \tag{B2}$$

$$\frac{\partial \delta}{\partial M} = 0 \text{ if } A + \mu - \lambda > M \tag{B3}$$

From (B2) it follows that the optimal M cannot exceed $A + \mu - \lambda$; from (B3) it follows that the optimal M cannot be less than $A + \mu - \lambda$.

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Table 1 – Descriptive Statistics

year	CEO	VOL	WTA	Sales	Profit
1993	1.9171	2.6242	422.79	2.5081	.15576
	.88776	2.8548	1414.7	1.1523	.09086
	86	86	86	86	86
1994	1.9769	2.5196	662.07	2.5593	.1653
	.84976	2.7456	2010.8	1.2081	.09787
	106	106	106	106	106
1995	1.9951	2.5771	820.73	2.5838	.167
	.84224	2.7202	2862.1	1.2889	.1056
	135	135	135	135	135
1996	2.067	2.6374	313.4	2.591	.17083
	.91067	2.5809	650.96	1.3036	.10933
	168	168	168	168	168
1997	2.3352	2.6668	387.77	2.6767	.17282
	.9748	2.5388	726.81	1.3468	.11687
	203	203	203	203	203
1998	2.3311	2.9636	1480.3	2.7453	.15535
	1.0132	2.6466	4572.7	1.3716	.14552
	252	252	252	252	252
1999	2.4945	2.9207	2407	2.8655	.16163
	1.0866	2.6566	8087.9	1.3866	.11414
	296	296	296	296	296
2000	2.5946	3.123	789.45	2.939	.15967
	1.7332	2.7949	1100.5	1.4251	.12155
	348	348	348	348	348
2001	2.5292	3.3385	451.23	2.8197	.11349
	1.4317	2.8099	553.41	1.4321	.19996
	421	421	421	421	421
2002	2.5902	3.5932	555.26	2.7923	.11387
	1.1737	2.868	869.07	1.4704	.1178
	492	492	492	492	492

year	CEO	VOL	WTA	Sales	Profit
2003	2.6358	3.79	454.44	2.8129	.11565
	1.1569	2.929	483.68	1.4921	.11572
	571	571	571	571	571
2004	2.8743	3.9968	693.61	2.8172	.13089
	1.127	2.9795	798.22	1.5209	.12661
	657	657	657	657	657
2005	3.0191	4.0751	1509.4	2.8536	.1355
	1.1938	2.9501	2760.8	1.5355	.15429
	710	710	710	710	710
2006	2.948	4.2614	748.83	2.7709	.12437
	1.1416	2.9521	1833	1.5667	.27191
	861	861	861	861	861
2007	3.0046	4.454	5777.3	2.6757	.12334
	1.0325	3.0168	21586	1.6085	.24852
	1052	1052	1052	1052	1052
2008	2.9397	4.5406	3564.2	2.7647	.11551
	1.1172	2.991	17653	1.5997	.29638
	1089	1089	1089	1089	1089
2009	2.8866	4.6218	6299.1	2.6384	.09375
	1.073	2.9467	30333	1.6179	.21747
	1126	1126	1126	1126	1126
2010	3.1226	4.5686	6213.4	2.742	.1305
	1.0624	2.8893	30128	1.5733	.27577
	1147	1147	1147	1147	1147
2011	3.1656	4.483	4674.1	2.8262	.11896
	1.2322	2.8649	18844	1.5945	.29182
	1177	1177	1177	1177	1177
2012	3.2375	4.4423	5882.3	2.819	.11463
	1.2297	2.8931	27193	1.5851	.23786
	1227	1227	1227	1227	1227
Total	2.8869	4.1117	3423.1	2.7659	.12458
	1.1934	2.957	18908	1.5416	.22594
	12124	12124	12124	12124	12124

Table 2

CEO Pay: Between-groups estimates

	(1)	(2) model2	(3) model3	(4) model4
WTA			0.00000415***	0.00000339***
			(4.09)	(3.34)
Volatility		0.0478***		0.0441***
		(5.93)		(5.43)
Sales	0.306***	0.326***	0.307***	0.325***
	(20.24)	(21.27)	(20.45)	(21.32)
Profit	0.416**	0.537***	0.372**	0.492***
	(3.07)	(3.96)	(2.75)	(3.62)
Constant	2.047***	1.771***	2.028***	1.776***
	(46.61)	(27.76)	(46.12)	(27.93)
Observations	12124	12124	12124	12124

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1

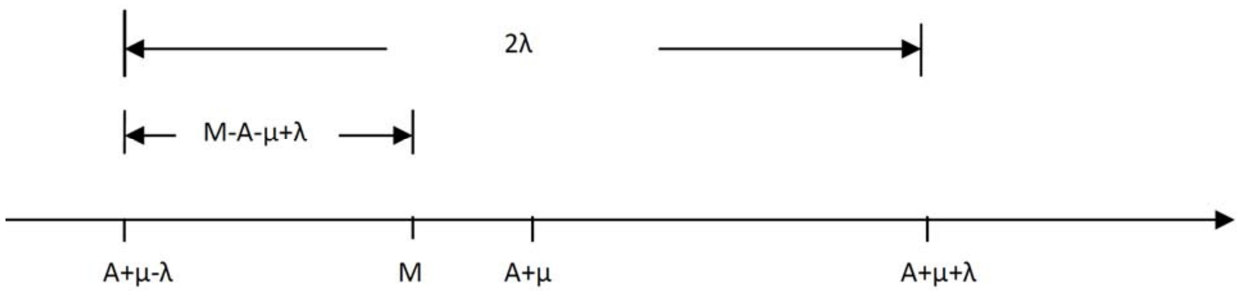


Figure 1a: $\delta = \delta_0 + (1-\delta_0)\ [M-A-\mu+\lambda]/(2\lambda)$

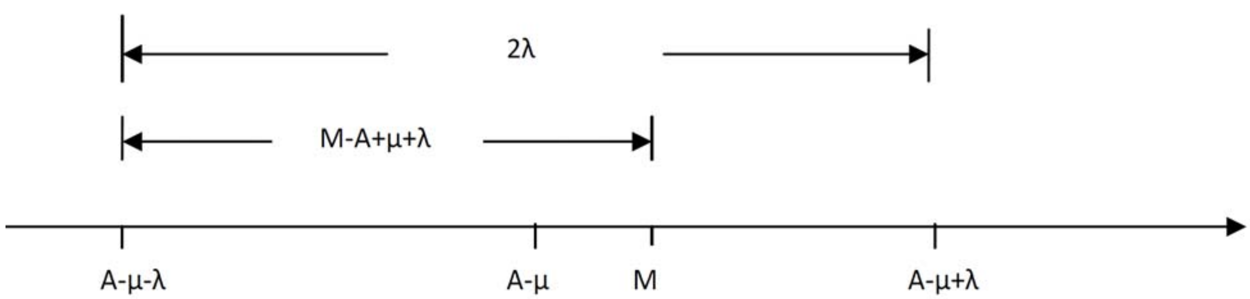


Figure 1b: $p+\delta=\delta_0 + (1-\delta_0)\ [M-A+\mu+\lambda]/(2\lambda)$

Figure 2

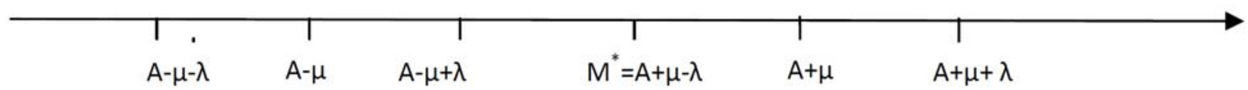


Figure 2a: $\mu > \lambda$, $\delta = \delta_0$, $p = (1-\delta_0)$

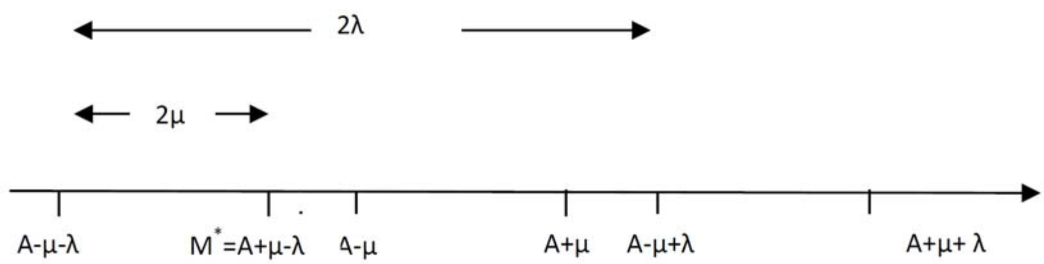
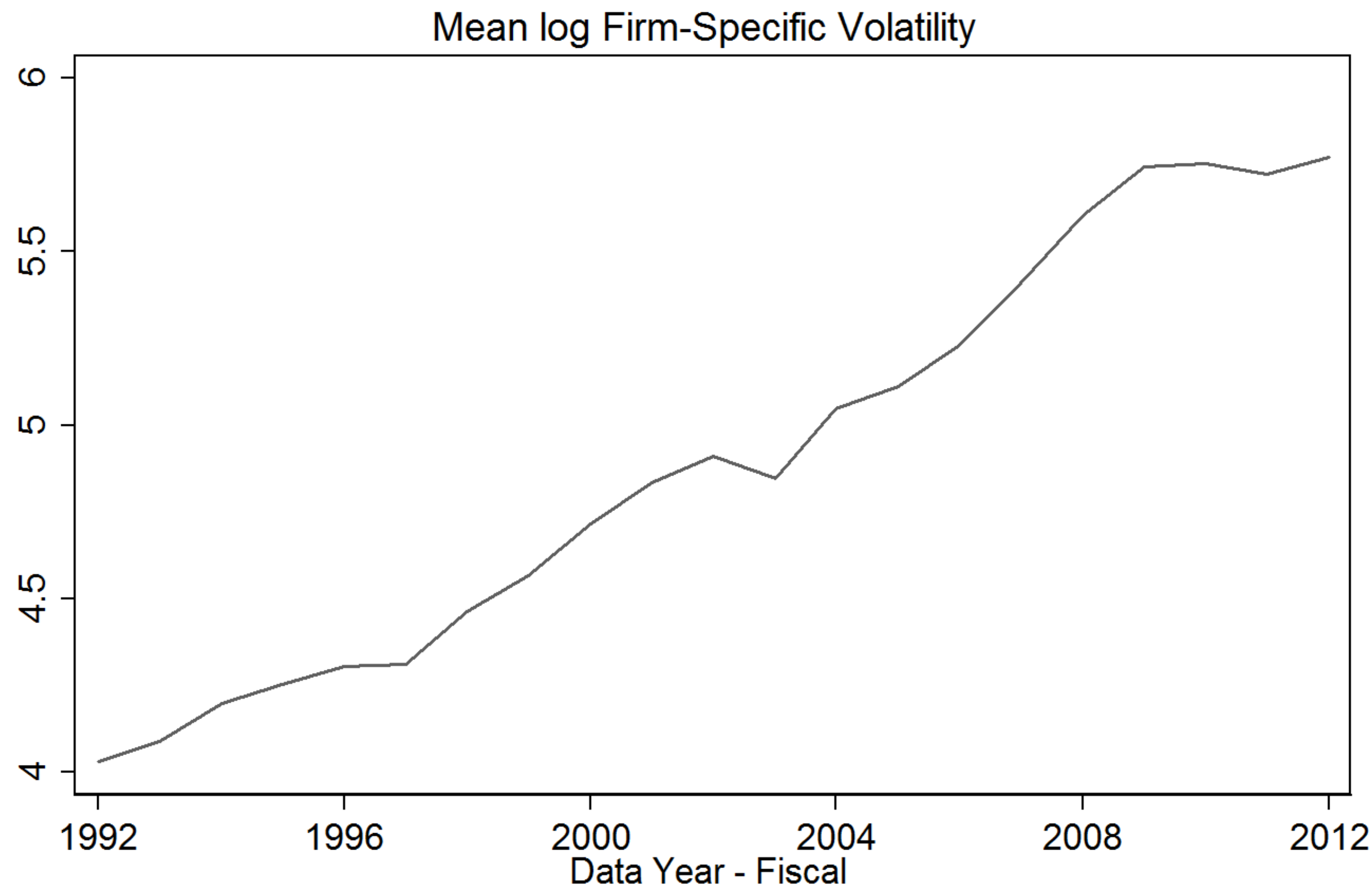


Figure 2b: $\mu < \lambda$, $\delta = \delta_0$, $p = (1-\delta_0)\mu/\lambda$

Figure 3



Mean log Firm-Specific Volatility
6
5.5
5
4.5
4
1992
1996
2000
2004
2008
2012
Data Year - Fiscal

Figure 4

Dispersion, by year
log Firm-Specific Volatility

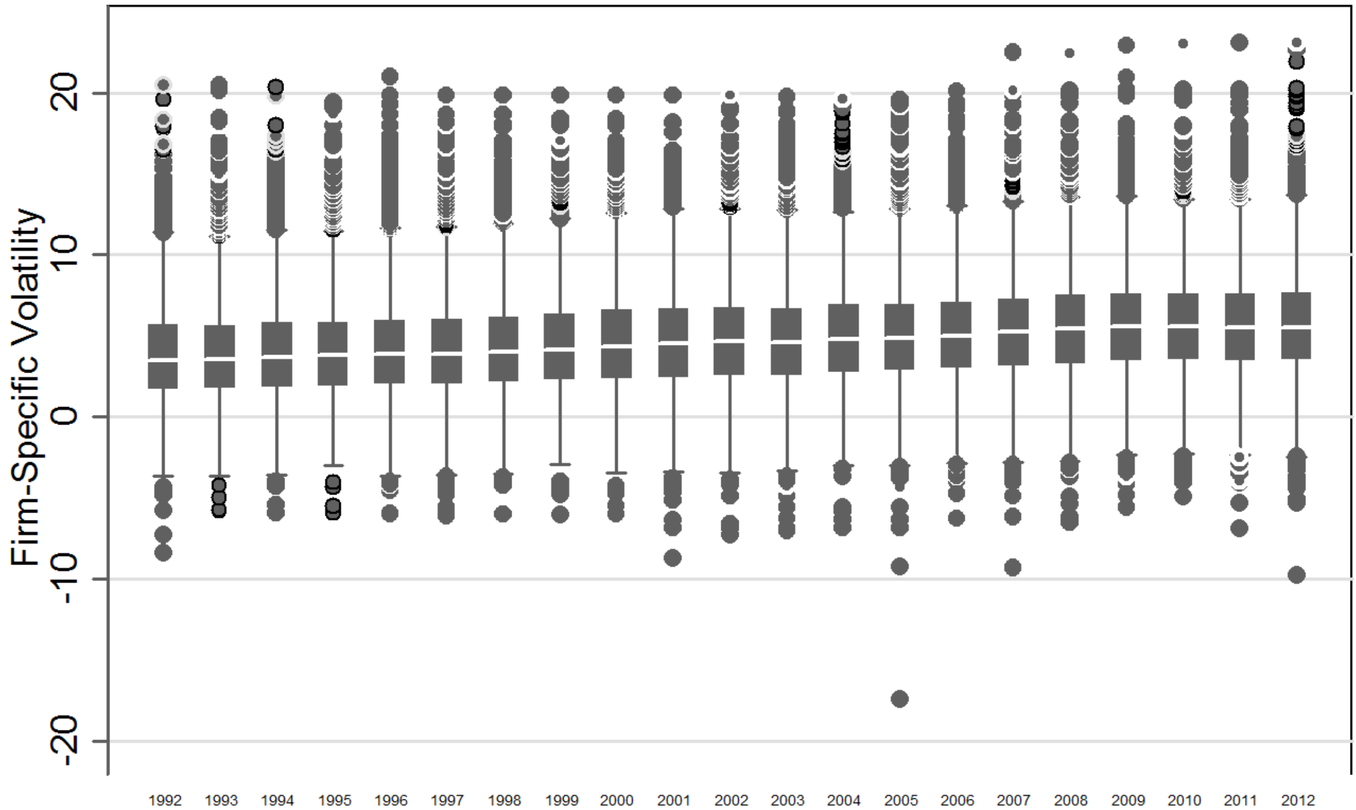


Figure 5

Profit:Employee - Mean of Industry SDs

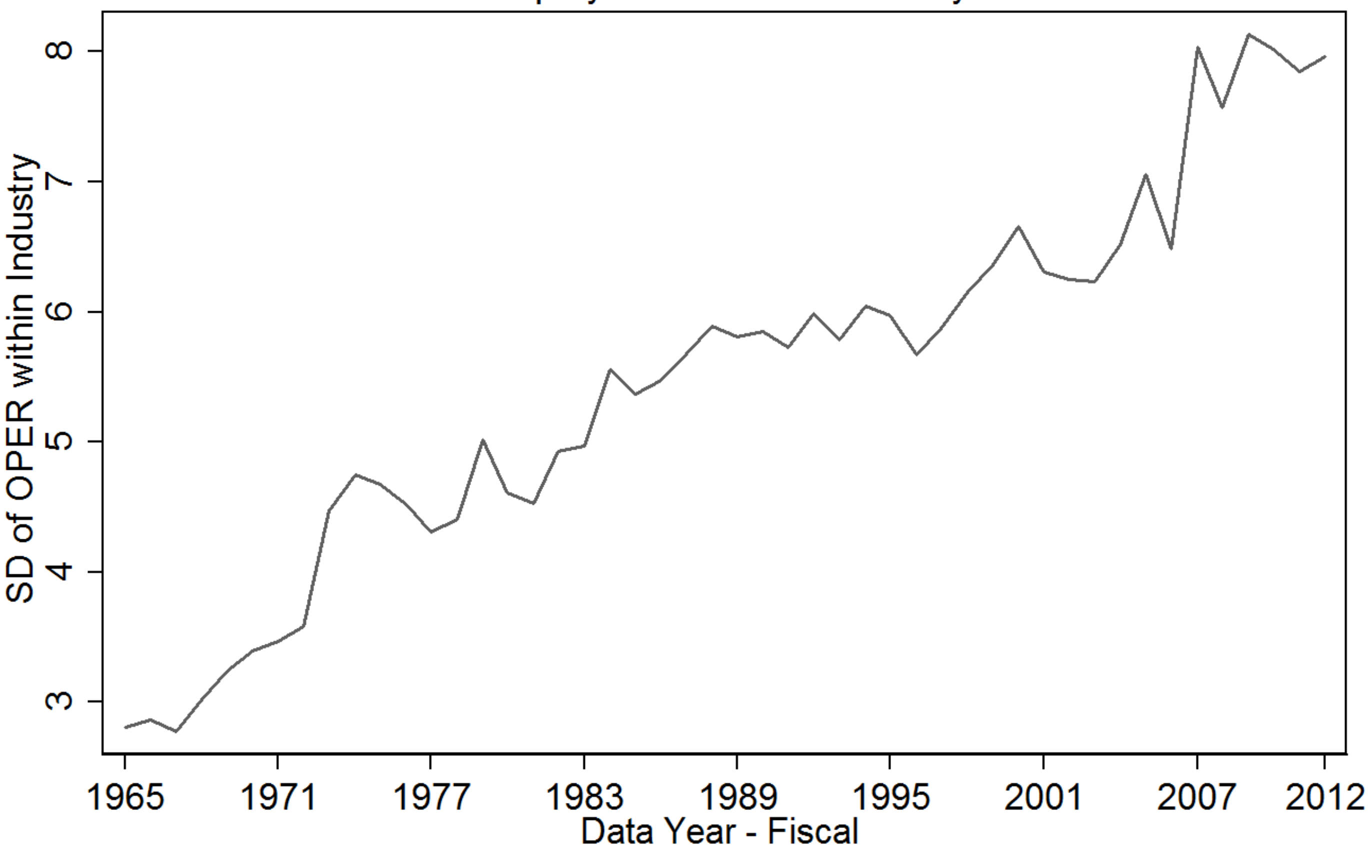
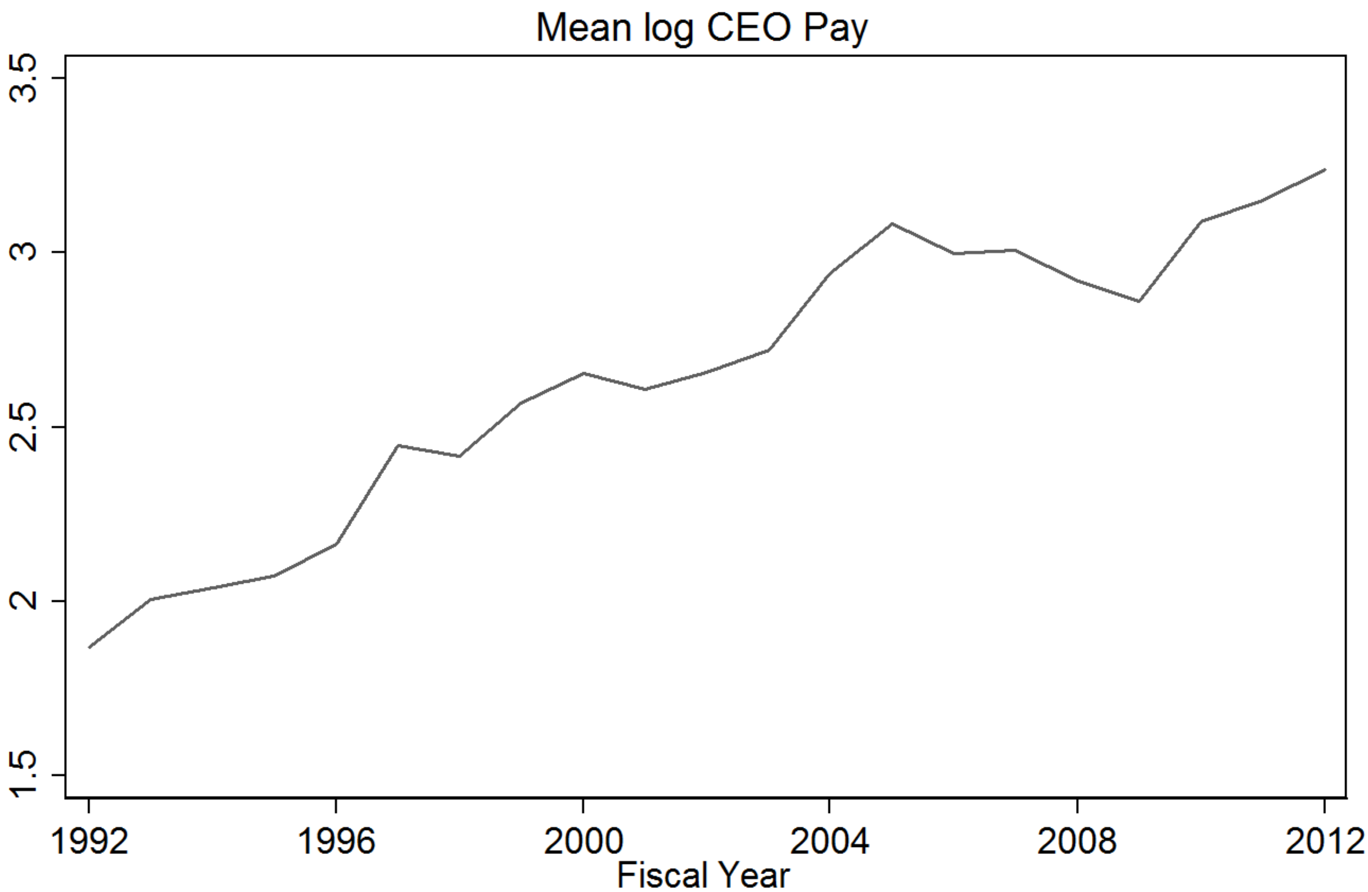


Figure 6


Mean log CEO Pay
3.5
3
2.5
2
1.5
1992
1996
2000
2004
2008
2012
Fiscal Year